

RECIPIENTS

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**Honeywell Clearwater
IBM Houston**



George M. Low TROPHY

NASA'S Quality And Excellence Award



FOREWORD

The National Aeronautics and Space Administration wishes to congratulate **The Space and Strategic Systems Operation of the Honeywell Space Systems Group**, Clearwater, Florida, and the IBM Federal Systems Company, Houston, Texas, the 1992 winners of NASA's **George M. Low Trophy**. The awarding of this trophy recognizes attainment of NASA's highest level award for contractor Quality and Excellence. This document celebrates the 1992 success of these two fine organizations and provides for others information about their outstanding quality programs.

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Honeywell Clearwater

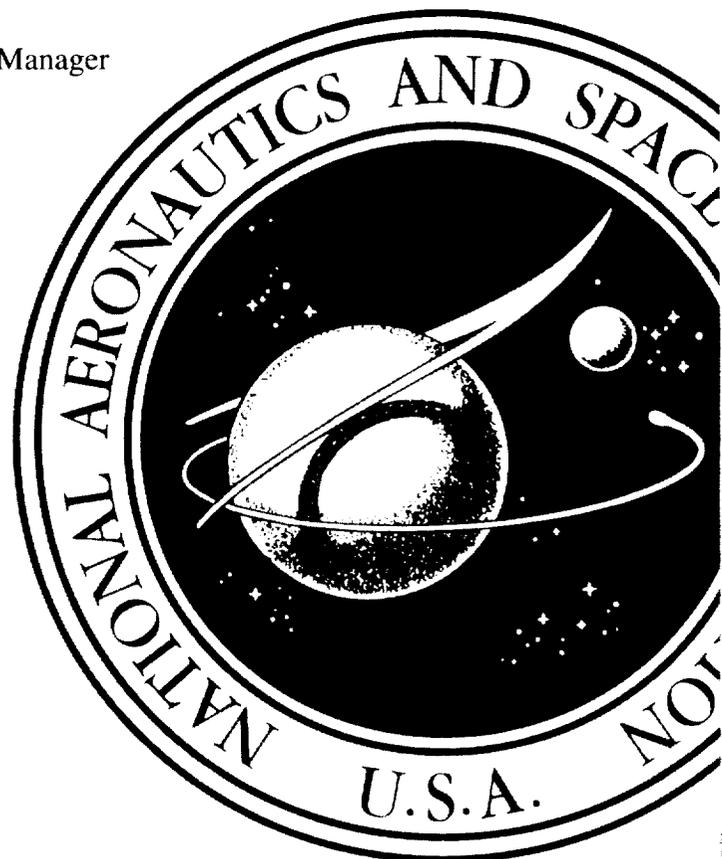
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The George M. Low Trophy

Stands 15" high and is comprised of a lucite replica of an Apollo Command Module mounted atop a hexagonal walnut obelisk. Imbedded with the lucite is a medallion bearing the likeness of George Low on one side and the NASA seal on the other. The cast medallion contains fragments of an artifact from Apollo II, the first manned lunar mission. On three of the obelisk faces are: medallions depicting NASA's mission; an inscription acknowledging the recipient of the trophy; and the following inscription acknowledging the awards history:

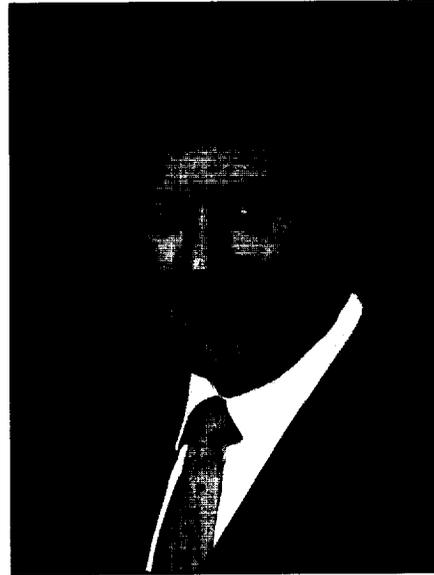
This trophy is awarded in memory of George M. Low, who greatly contributed to the early development of NASA Space Programs during his 27 years of Government Service.

The medallion, which is embedded in the shape of an Apollo Command Module, has alloyed in it a portion of an artifact flown to the moon and back on Apollo 11—the first manned lunar landing mission July 16–24, 1969.

I N T R O D U C T I O N

Honeywell's total quality initiative results from our commitment to providing superior quality products and services. Our Total Quality Involvement (TQI) process is based on our decision to strive for continual improvement, both individually and by working together across all functions of the organization. Through teamwork and a positive attitude, we seek to satisfy customer needs in the most productive and efficient ways possible.

We believe TQI can succeed best in a culture that encourages and welcomes new ideas. We know that successful TQI depends on involvement by everyone within Honeywell.



Our firm is committed to TQI because we believe it holds the promise of satisfaction for our customers, success in our business and increased job satisfaction.

Space Systems Group designs, develops, manufactures and supports products for guidance, navigation and control of launch vehicles and spacecraft. Our support to NASA spans four decades of space exploration. We are proud of our contributions to the country's space program and of the relationships we have built over these decades through our quality initiatives and commitment to customer satisfaction.

Achieving our mission to be the preferred supplier of control products and systems to the U.S. space and strategic markets is dependent on our ability to deliver products that meet or exceed all quality, performance and contractual requirements. Our understanding of our customers' quality requirements results in delivery of products that are reliable and meet client acceptance criteria and performance requirements.

We are proud of our people, our products and our history of customer satisfaction. We are especially proud to be one of the recipients of the George M. Low Trophy for 1992.

Carl L. Vignali
Vice President, Group Executive

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HONEYWELL CLEARWATER BUSINESS PROFILE



Aaron Cohen on right and Bill Poe with George M. Low Trophy

Quality Journey for Decades

The Space and Strategic Systems Operation (SASSO) of the Honeywell Space Systems Group (SSG) is located in Clearwater, Fla. Our facilities include eight buildings totaling 800,000 square feet on a 100-acre campus. Approximately one-fourth of this floor space is devoted to manufacturing, with the balance for design, development, test and support functions. We employ approximately 2,000 persons.

Honeywell controls have been on every U.S. manned spacecraft to date from the first Mercury capsule to the space shuttle orbiter. Some of Honeywell's products include:

- Attitude control and determination systems
- Guidance and control systems
- Inertial guidance components (such as gyros and accelerometers)
- Memories (plated-wire and thin film)
- On-board signal/data processing systems

- Radiation-hardened microelectronic products
- On-orbit applications (guidance; navigation and control systems; data management and processing systems; and mechanisms and pointing systems)

Honeywell's Space Programs

Our space program involvement has been extensive from the word "liftoff." On the space shuttle, we've developed flight control systems, a main engine controller, multiplexer/demultiplexers, cockpit upgrades and numerous other detailed mechanisms that ensure mission success.

Our customers range from the U.S. Department of Defense and NASA to commercial space enterprises, Sandia National Laboratories and prime contractors which serve these agencies. Honeywell's SSG has designed the devices and systems for a complex range of rockets, boosters and programs for our clients. A few include:

- Launch vehicles: Centaur upper stage, transfer orbit stage and medium launch vehicle TITAN IV.
- Peacekeeper: Third-generation gyro, specific force integrating receiver and plated-wire memory.
- Trident: 10 PGA (pendulous integrating gyroscopic accelerometer) and plated-wire memory.
- Sandac V: Parallel processing computer.
- Galileo: Spin bearing and scan drive assemblies.
- Magellan: Reaction wheels.
- Gamma Ray Observatory: Reaction wheels.

Honeywell's Record in Space

SSG's support to the U.S. space program spans more than three decades of planetary exploration and space flight. We have been a key contributor to every NASA manned space program and have made significant contributions to major U.S. unmanned launch and exploration vehicles and satellites. We have substantial roles on the U.S. space shuttle and space station programs.

For the shuttle, our main engine controllers monitor and control the system's three liquid-fuel engines, including throttling them up and down. A flight control system directs the

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vehicle's flight, its multiplexers link the electronic systems throughout the mission and its automatic landing system is a backup to the shuttle crew. Honeywell also produces the two hand-control systems for the shuttle's manned maneuvering units strapped to the astronaut's back.

Space shuttle crews also receive training in landing the orbiter by flying converted business jets for nonpowered landings. A Honeywell airborne digital computer is coupled with Honeywell autopilots and instruments to program the shuttle's flight characteristics into the plane's flight control system.

In weapons systems, we maintain a strong position in precision instruments for the two U.S. strategic missile programs. In launch vehicles, we are the selected guidance system supplier on two of the three contemporary U.S. launch platforms. In satellite processing subsystems, we are leaders in high-speed integrated circuit computer system development. Overall, our market share is 19 percent, with our nearest competitor at 10 percent of the market.

Honeywell's Quality Emphasis: Nothing New and Always New

SSG's journey of quality began in the 1970s with the implementation of quality circles. Efforts in the '70s and '80s were characterized by many starts and stops and individual departmental efforts, with no coordinated connection. However, in late 1988, the location general manager established an initiative with the senior executive staff to develop and implement location-wide quality and improvement.

The senior executives also developed objectives for continual improvement, as well as for strategies to accomplish the goals. But figuring out a name to call the process was a head-scratcher. The feedback from staff was "don't call it Total Quality Management or it will be perceived as a management program." Subsequently, SSG settled on Total Quality Involvement (TQI) as an appropriate name.

We wanted everyone to be involved in looking at their total job to improve the quality of that job.

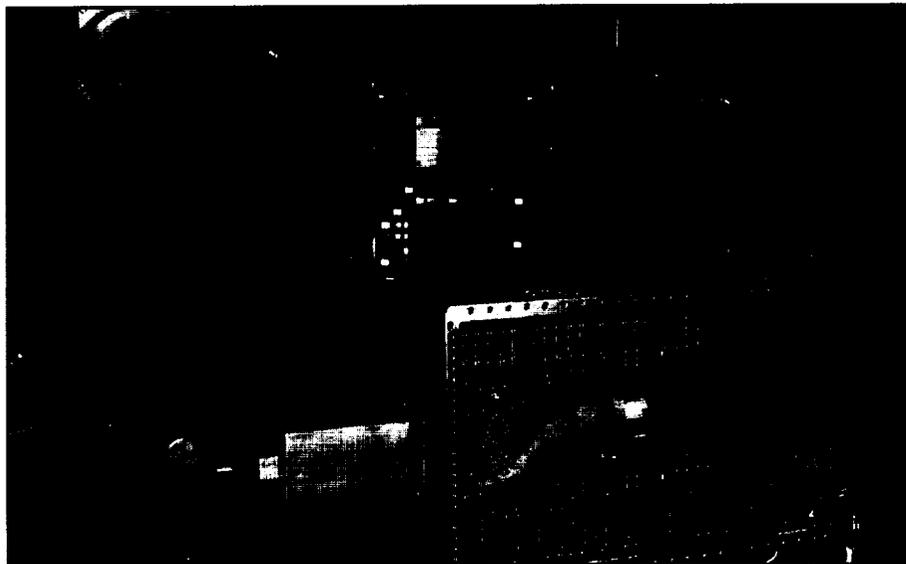
At SSG, we are proud of our TQI initiative and the results we have realized since its inception. These results have been achieved through the hard work, creativity, skills and dedication of our employees.

Definitions of Quality

Achieving SSG's mission to be the preferred supplier of control products and systems to the space and weapons programs is our ability to deliver products that meet or exceed all quality, performance and contractual requirements. Our systems simply are not to fail, especially when functioning in the farthest reaches of space and under the worst conditions. Building customer confidence in the ability of our products to perform without failure is accomplished through direct participation by that customer in all phases of design, production, test, delivery, installation and use.

SSG has well-defined attitudes about quality, understood by everyone from line worker to vice president to customer. They are:

- Quality -- consistently meeting customer



Honeywell employee inserts a test adapter in the prototype Space Shuttle Main Engine controller-Block II

needs, from cost, schedule and performance, while meeting the growth and financial needs of the organization.

- Total Quality -- the implementation of quality, first time and every time, in every function; at all levels of the business for internal and external customers and suppliers.
- Total Quality Management -- the culture of total quality such that we strive for continual improvement, individually and by working together, across all functions of the organization.

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Management of Process Quality

Our products are custom-designed, not off-the-shelf. The design process itself has three phases:

- The definition phase extends from first customer contact through preliminary review, where we determine, analyze and document the customer's requirements. Once understood, we capture the requirements in a series of hardware and software specifications, which are accepted by each unit of the organizational team.

- Implementation includes frequent internal reviews, electrical and mechanical analysis and engineering tests. After the critical design review, the design is formally approved and released.

- The verification phase consists of more extensive tests and analysis on the production version of the product. Independent and customer review teams complement our own internal testing.

Providing data to our customers is an important service. We document our design and production processes, describe the testing, document the results and provide traceability from the finished product back to the raw materials. Improvements are subject to verification at all steps of implementation and development.

As ownership of the product passes on to the customer, SSG continues to strive for total customer satisfaction by validating our four basic customer needs: dependable supplier, best price, quality products and on-time schedule performance.

Concerned Management

The Executive Steering Committee (ESC) was established in November 1988 to develop a location-wide quality and productivity improvement program. Chaired by the SSG group executive and including his entire Clearwater staff, plus the director of product assurance,

the committee meets for three hours every two weeks to :

- Analyze feedback from customers and employees.
- Assess progress of customer satisfaction and quality initiatives.
- Establish short- and long-term customer satisfaction and quality goals and determine strategies to achieve them.

THE HONEYWELL QUALITY PROCESS

- Formulate new quality initiatives or improve existing initiatives.
- Allocate resources.

ESC members, plus staff who report directly to the vice president of operations, spend more than one-third of their time in TQI-related activities. This emphasis on quality from the top to the lower layers of management demonstrates to each worker its importance. Subsequently, a passion for quality permeates every SSG operation.

In 1992, the ESC expanded Honeywell's mission and guiding values to include expectations for success and quality performance. These are integrated into performance appraisal systems used for all levels of employees. Company expectations for employees range from conforming to the highest ethical standards to demonstrating respect for coworkers and customers. From the company, employees can also expect adherence to superlative ethics, as well as effective leadership and clear direction, a safe and healthy work environment, fair and respectful treatment, recognition for accomplishments, excellent tools and training and open and honest communications.

Information about quality has been passed along to customers and workers in various ways since the ESC was established:

- Quarterly TQI management forums started in 1988.
- A TQI resource kit created in 1989 and upgraded to a TQI handbook in 1992.
- Distribution of Honeywell's strategic priorities booklet to an all-employee meeting in 1990.
- "Our Commitment to Quality" booklet distributed in 1991.
- A total quality calendar distributed to all employees in 1991.
- TQI posters mounted throughout the SSG complex in 1992.
- Distribution of a four-inch by six-inch standup card to all employees in 1992, display SSG's mission, vision, guiding values and expectations.

Workbooks and ad hoc courses taught by department experts complement the range of offerings.

**“Superlative ethics,
as well as effective
leadership and
clear direction”**

Employee Involvement

SSG uses two principal means to encourage involvement of all employees in TQI activities:

- The Great Ideas suggestion program was revitalized in 1990 by simplifying forms, streamlining the approval process, incorporating uniform financial rewards and encouraging submission of ideas with intangible savings. One of the keys to the success of the Great Ideas program was the granting of authority to an employee's immediate supervisor to approve an idea without having to go through higher level authorization or a central control group. In the first year of the new program, suggestions more than doubled: from 1,300 to 2,800.

- TQI Process Improvement Teams are involved in key business processes. Seven full-time facilitators are available to help with problem-solving techniques as necessary. Currently, 374 teams are functioning within the complex, with members including staff and customer representatives. Fifty-five percent of all SSG employees participate on at least one team. On a monthly basis, senior executives attend randomly selected team meetings to learn about their activities and reinforce the importance of continual improvement.

Teams are rewarded by cash awards, gift certificates, newsletter articles and selection for recognition at ESC forums.

Customer Focus and Satisfaction

SSG maintains close contact with customers throughout the design, development and manufacturing process. SSG strives to fulfill four basic customer needs:

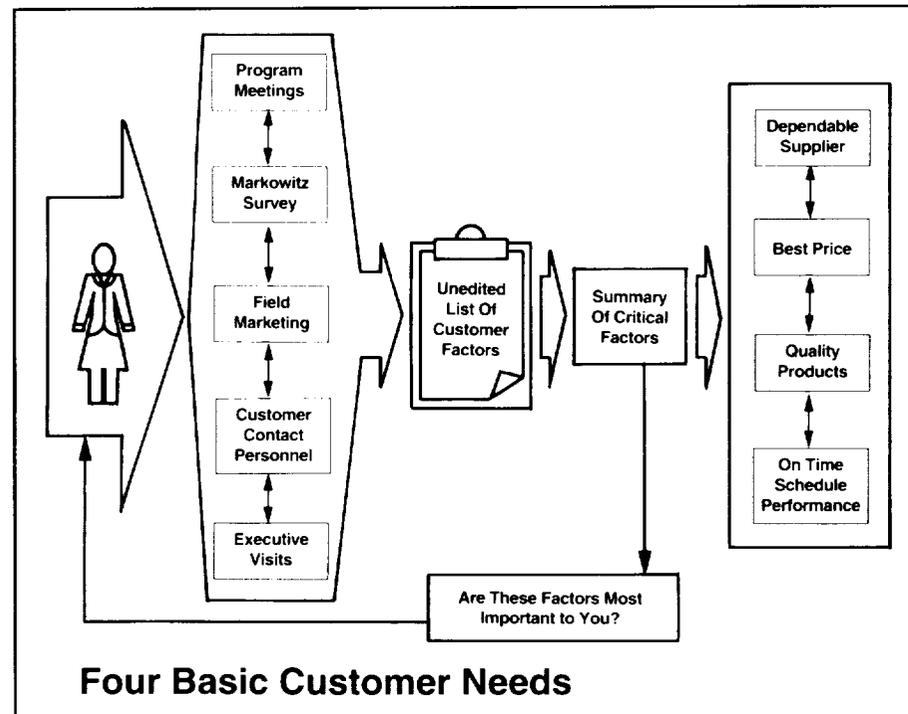
- Dependable supplier -- The key factor in customer relations is that SSG products and employees do what we commit to do for requirements explicitly in the contract and those that are implicit in our relationship. We also work closely with the customer to sell the customer's product or program to the end user, usually the government or NASA.

- Best price -- Price has been the deciding factor in every major procurement in the past year. Building close relationships with customers on existing contracts helps give us insight into price factors on future opportunities.

- Quality products -- Products that conform to all contractual specifications and requirements or enhance mission performance are critical to the customer meeting contractual requirements.

- On-time schedule performance -- Since our products are frequently integrated by our customers with products from other vendors prior to the end product to the government, it is critical that we meet scheduled due dates.

We employ the independent research firm of Markowitz and McNaughton to conduct annual surveys of our major customers, as well as perform our own field marketing. These activities help keep us on track as to customer expectations and demands, ensuring that continued service and quality performance standards are met. Demonstrated performance excellence has resulted in numerous awards from NASA, Rockwell, Lockheed, Marshall Space Flight Center, General Dynamics and others.



QUALITY AWARENESS

SSG encourages employee leadership and involvement in professional organizations and local community projects as a mechanism for sharing SSG's values and quality initiatives with other organizations in our community.

The company provides financial support for professional society memberships and reimburses employees for expenses associated with attending monthly meetings, attending

seminars conducted by associations, speaking at national conferences and participating in special projects. Through this program, employee membership in the local chapter of the American Society of Quality Control has grown from 22 to 50 in the past two years. Other activities that demonstrate SSG's commitment to promoting quality awareness within the community include:

- Providing more than 100 employees to local schools to help tutor and mentor children.
- Participation with the Air Force in an exchange program that permits Air Force employees to work in our facility for six months.
- Providing consulting support to Abilities of Florida -- an organization that helps rehabilitate people with serious physical and mental disabilities back into the work force. SSG assisted Abilities in developing a strategic plan and enhancing the systems, processes and efficiency of its manufacturing department.
- Preparation of a 90-minute presentation for the University of South Florida TV network as part of its graduate course on TQM.
- The group executive served as 1991 campaign chairman for the United Way of Pinellas County and used this position to promote quality awareness with local companies. In addition, Honeywell provides assistance to this organization through a loaned executive program.
- Sponsoring a team member and team leader training seminar for the teaching and administrative staff of Highland Lakes Middle School.
- Working with the Pinellas County School Board to help it set a mission; combine similar programs for a singular focus; and analyze its organizational structure.

“SSG encourages employee leadership and involvement in professional organizations and local community projects. . .”

suppliers to improve material acquisition processes at Honeywell and the suppliers. Since 1985, quality yields have increased from 92 percent to 97 percent.

In recognition of this continuously improving support to SASSO, our current 24 MEP suppliers were invited to Clearwater, on Oct. 27, 1992. The suppliers were informed by Bill Cummings, Director of Materiel, about future material acquisition activities. Otto Coldiron, Director of Total Quality, provided information on the TQI program and its accomplishments. Jim Acker, Director of Programs, presented an overview on business pursuits and our overall thrust toward increasing partnerships and teaming relations with our customers. Supplier Recognition Day was deliberately timed with our campus TQI celebration week and some suppliers brought displays to demonstrate their TQI efforts.

Supplier Recognition Day activities included a luncheon held at the Tampa Bay Conference Center, where each supplier received an MEP recognition plaque to be displayed on their campuses. Currently, we are in the process of formally certifying several of these MEP suppliers to further emphasize supplier responsibility for process control.

HONEYWELL DEVELOPMENT PROCESS

Computer Integrated Manufacturing

SSG is a low-volume producer. We build only a few of any one product, with the key measurements of dependability and quality being mission success, customer hardware acceptance and reliability.

To help in this process, Computer Integrated Manufacturing and Design has become part of doing business in Clearwater. Information technology requirements embodied in the Department of Defense Computer-aided Acquisition and Logistics (CALs) and NASA Technical Management Information System (TMIS) initiatives are met through the use of our computer-aided design (CAD) and computer-aided manufacturing (CAM) systems. The accompanying diagram reflects the computer system functions as they relate to SSG's functional groups and programs.

Our CAD tools provide design engineering with the ability to increase design cycle control, produce error-free design and perform rapid uniform changes to meet customer needs. These tools also provide the engineer with the capability to perform sophisticated computer analysis and simulation during the product

SUPPLIER RECOGNITION PROCESS

In 1985, the Material Department implemented the Material Excellence Program (MEP) with our key suppliers. This program represented a significant change from the traditional price-only competition, minimal feedback relationships of the past, to a partnering and comprehensive performance feedback system.

The Procurement/Material Quality Assurance team expended considerable effort analyzing on-going performance data with

definition and design cycle.

Honeywell engineers use the CAD tools for electrical and mechanical design, schematic creation, automatic placement and routing, assembly drawings, detail drawing, and to produce complete documentation packages for the customer.

The Computer-aided Manufacturing Systems use a shared data environment where the Computer-aided Design, Manufacturing and Business systems provide data efficiency and integrity. Manufacturing systems used to manage the business include configuration management, process planning and delivery, manufacturing resource planning, factory data collection, stock room management, and quality information.

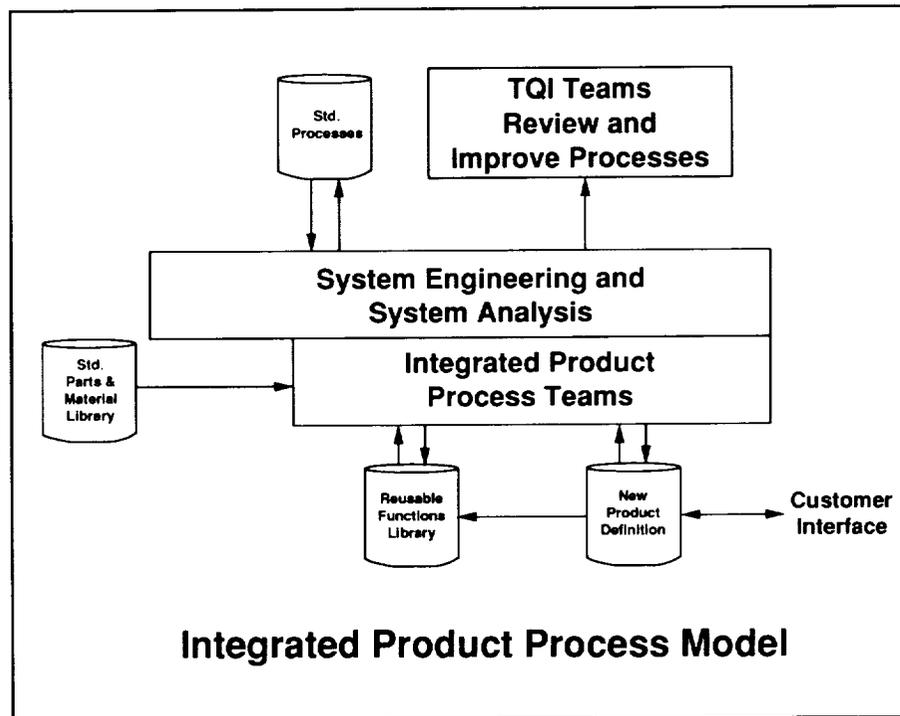
The manufacturing systems provide us with the ability to better manage our resources and control our processes. The process planning and delivery system, linking with the CAD system, provides our production and quality engineers with the tools to electronically create and deliver work instructions to the factory floor. This reduces cycle time and the possibility for errors during manufacturing. The combination of our systems ensure that we have the correct materials and resources in place for faster service, while meeting customer specifications at the same time.

Linking the CAD systems with the manufacturing and business systems has provided us with the tools to better implement concurrent engineering practices on new as well as on-going programs. Use of the CAD/CAM systems by all divisions has also provided tools to improve the TQI. The combination of these systems allow us to plan and manage our resources to produce the highest quality product for our customers.

INTEGRATED PRODUCT DEVELOPMENT

Integrated Product Development (IPD) and Total Quality Involvement (TQI) are different, but complementary philosophies. IPD organizes high-performance teams for the effective, efficient and rapid development of projects on programs. TQI is concerned with teams applied to continually improve the processes within a business enterprise. IPD is focused on products. TQI is focused on work processes and their improvement. Both depend on people working as part of teams. We are merging these two philosophies.

We have concentrated much of our energy for improvement at the department level, using the organizational improvement flow chart to guide our efforts. A shortcoming of IPD, as currently defined, is its neglect of a mechanism for including TQI. A shortcoming of TQI, as

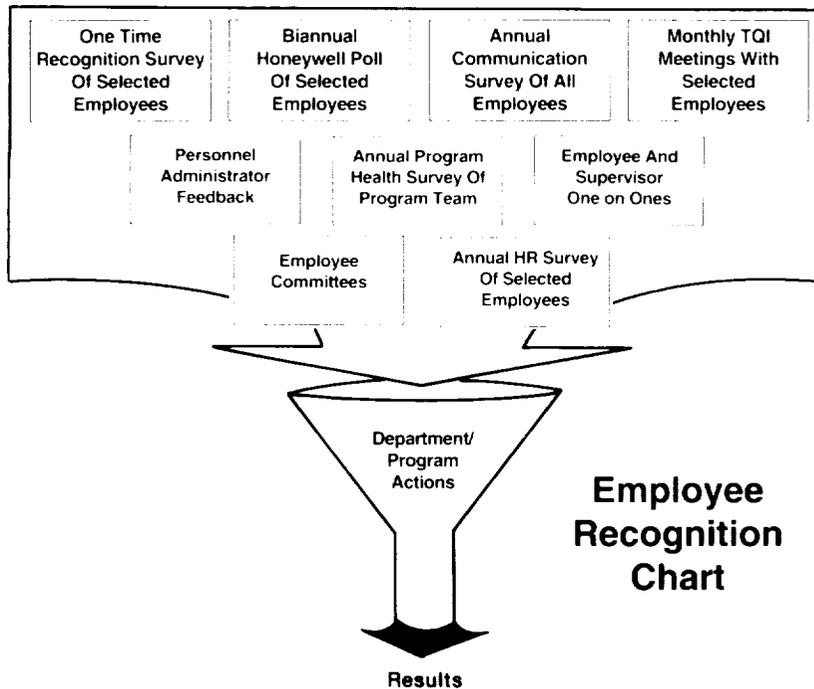


currently practiced, is its focus on departmental or functional processes. These shortcomings can be overcome. The problem can be stated as, "How to continually improve everything associated with project development when projects are organized in accordance with IPD principles?"

Last year, we developed the integrated product process model. The "product processes" included are those that are potentially common within a product area and across product areas. This begins with a design-to-specification and

ends with a fully spec-compliant product. All activity that defines the product information packages is included within a particular product process: such as parts list, layout, artwork, assembly drawing, circuit analysis, thermal and structural analysis, parts application review, Feature Mode and Effects Analysis (FMEA), reliability prediction and test-to, built-to, inspect-to and support-to requirements.

Databases and configuration management are needed for in-process release and updates to each product process and each new product. Management of the tremendous amount of data created by computer-aided design tools is a



Employee Recognition Chart

major current challenge. As a minimum, a product process is controlled by a standard containing an A-size drawing of the process, a short narrative describing the steps for each level of process rigor (the highest is manned or high value payload and other flight equipment; the lowest is nonflight or experimental), a qualified manufacturer listing (QML) -- such as a control checklist, a linkage to the design requirements checklist (DRCL) and references to templates for key contract data requirements list (CDRL's).

Employee Recognition

Honeywell's strategic plan is linked to individual employee performance objectives through a management process that incorporates job assessment, feedback, recognition and rewards.

The performance appraisal system consists of three major parts: a section for goals and objectives; another for evaluating performance factors; and an individual improvement plan.

Regular one-on-one discussions between management and workers take place at all levels. These discussions allow work-related problems to be resolved before crisis stage and permit assistance on other, more personal, levels if appropriate. Performance is reinforced through merit pay increases.

Since 1989, expenditures per employee for rewards and recognition increased from \$268 to \$353. Outstanding Work Product Performance, Secretarial Achievement Recognition, Work Center Team Initiative, Outstanding Engineer, Top Performer's Club and the Whatever It Takes Community Service are among the numerous nonfinancial awards presented on a regular basis to the SSG work force.

Education Possibilities and Involvement

Continuing education and training efforts are focused on improving the skills needed by teams and individuals to achieve their goals and those of the company. Technical, computer and production skills courses are available for different categories of employees because commitment to continual learning and self-improvement is one of Honeywell's expectations for its workers.

A TQI "training chair" was established in 1992 to evaluate TQI training, coordinate delivery and initiate new courses. A TQI support team helps provide meeting facilitation and management consultation to all SSG departments.

Both in-house and external instructors are available for dozens of other classes in many job-related fields. By utilizing this diversity of teachers, Honeywell ensures high interest and quality programming.

After-hours courses with an indirect and gradual impact on work performance such as "Planning for Retirement" are offered for employees and spouses. Live, interactive satellite courses on current topics, video courses

and workbooks and ad hoc courses taught by department experts complement the range of offerings.

Employee Well-being and Morale

Honeywell accepts its commitment to providing a safe work environment and has taken numerous steps to ensure that fact.

- In 1992, we instituted a health incentive program called Script for Life where workers are evaluated on a number of health-related factors. Those who meet the screening criteria receive a \$200 health incentive. This program is supplemented with training in how to stop smoking, encouragement of weight loss and other behavioral changes.

- Monitoring for possible health impact from dangerous chemicals and other hazards is regularly conducted.

- Ergonomics-related injuries are immediately investigated and a physical audit is conducted on the respective work area to determine the cause of each injury.

- Special services to employees and families are available, including the Honeywell Child Development Center which includes a Caringwell for infants through 5-year-olds and a Learningwell for kindergarten through second grade.

- An In-Hospital Child Care program with three hospital-affiliated sick child care centers. Participating hospitals include Bayfront Medical Center, Morton Plant Hospital and Sun Coast Hospital.

- An At-Home Sick Child Care program with Teddy Care for Kids from Family Service Centers of Pinellas County, Inc. Certified home health aides or licensed practical nurses care for children who are too ill to go to school or day care, who are recovering from surgery, or who have infectious diseases such as chicken pox.

- A Family Leave program that provides for an unpaid leave of up to six months while continuing employee benefits. The unpaid leave assists employees who are faced with child birth, adoption, pressing family business and care of an elderly parent or other dependent.

- Sports facilities such as volleyball and handball courts, softball fields and a walking/jogging track contribute to the sense of well-being on the part of workers and management.



Caringwell Dedication—Honeywell Management and Dependent Children

Community Involvement: Important and Necessary

Active financial, technical and professional support for the local community is a Honeywell hallmark. Executives, middle management and other staff have a stake in the upkeep of their Clearwater neighborhood. Their involvement has taken many forms:

- The group executive served as 1991 campaign chairman for the United Way of Pinellas County and used this position to promote quality awareness with local companies. In addition, Honeywell provides a loaned executive program to the United Way.

- SSG sponsored a team member and team leader training seminar for the teaching and administrative staff of Highland Lakes Middle School.

- The firm worked with the Pinellas County School Board to help it set a mission; combine similar programs for a singular focus; and analyze its organization structure.

- In the Old-Limp-ics, money is raised for Special Olympics.

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PROCESS FLOW ANALYSIS

Carl Vignali sent a letter January 2, 1990, to all SSG management that included the following message:

"We have defined our TQI philosophy and approach during 1989, it has become evident to us that TQI itself is a process."

"Because TQI is a process, we have put it into the form of process flow charts -- one for the organization and one for individuals. These process flows are attached, along with a narrative which explains the activity which should happen at each block."

According to Vignali's letter, the TQI process flow chart indicated that one of the more important steps in the procedure is the formation of teams to analyze and improve the entire operation.

He explained the approach as follows:

see where it can be simplified and/or improved. Maybe

steps or actions can be combined or eliminated to shorten cycle time. The sequence of events could be changed to improve work flow. Methods may be discovered to prevent mistakes. Each step should be reviewed and the process in total should be also reviewed. As each review is completed, the next highest priority activity is then started."

TQI TEAMS

We currently have more than 300 teams involving approximately 1,200 employees pursuing process improvements in virtually every phase of the operation. Many of these teams are formed by employee initiative to improve a process that affects their work group. Others are formed by management to address a broader cross-functional process.

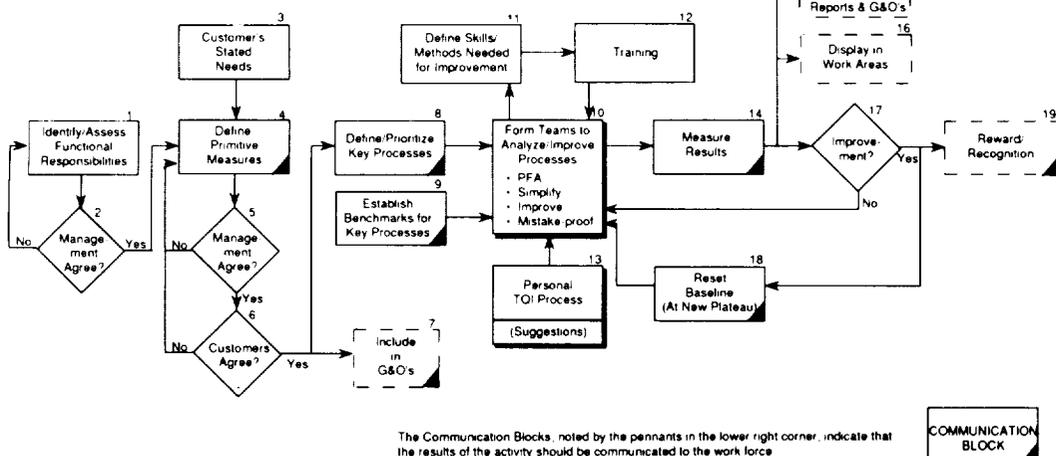
Listed below are examples of process improvements that are currently being worked by TQI teams:

- Hazardous Waste Handling Error Reduction
- Information Systems Application Support Improvement
- Cooling-Tower Treatment System Efficiency and Safety Improvements
- Intergraph Software Modification Control
- Space Shuttle Flight Control Cost Report Automation
- Space Shuttle Main Engine Controller Incentive Program
- Action Register Improvement
- Customer Service Performance Improvement
- PC Acquisition Process Improvement

- Workmanship Standard Improvement

Productivity has significantly increased over the past six years as a result of improvements accomplished by these TQI teams in a number of fields such as revenue, profit, average investment, investment turnovers and revenue per employee.

TQI Process - Organization



The Communication Blocks, noted by the pennants in the lower right corner, indicate that the results of the activity should be communicated to the work force

The process Support Blocks, noted by the dotted lines, while technically not a part of the process, are important in keeping the continual improvement process working

COMMUNICATION BLOCK

PROCESS SUPPORT BLOCK

"This is where the fun starts. Everything up to this point has been necessary, but it hasn't improved anything yet! Taking the highest priority process (the one having the most effect on the group's performance), a team should be convened to analyze the procedure and find ways to improve it. The steps might be flowed out (defined) so that everyone fully understands it. Segments of the process are then looked at to

I N T R O D U C T I O N

If you asked our employees what IBM did to win NASA's Quality and Excellence Award for the second time in five years, they probably would tell you, "nothing special."

That's because we have an unusually strong "quality culture" at IBM. It pervades every part of our organization and affects everything we do. We are driven to give our best for two reasons.

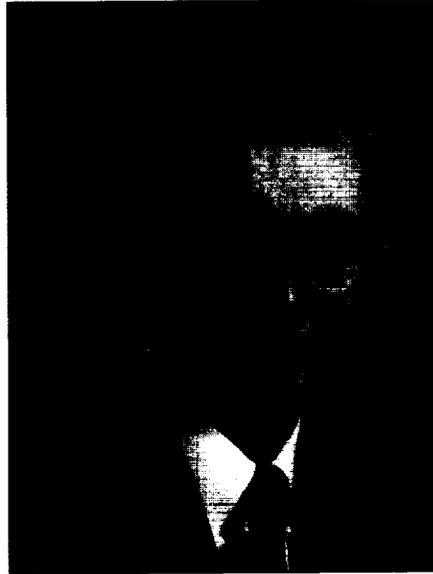
First, we do it because we want to. For many of us, working for NASA is the fulfillment of a childhood dream. We are proud to be part of the U.S. space program. We are privileged to be part of history. We feel fortunate to work for a customer like NASA that is the best in the world at what it does.

Second, we do it because we have to. Our customer demands it. NASA requires that our computer hardware and software be absolutely perfect. There is zero tolerance of errors in manned space flight. Millions of dollars, precious human lives and the prestige of the nation ride on the quality of our work.

Our obsession with quality goes beyond mere professionalism. It's personal. As one of our senior engineers said, "Some of the astronauts are our neighbors. My family sits next to their families in church. I feel a big sense of responsibility for them. That makes quality imperative."

In the next few pages, you will read about a few of the many impressive things IBM employees have done to win the George M. Low Trophy. Truly, the credit belongs to them. For more than 30 years, NASA has challenged them to do the difficult and they have met that challenge--consistently, brilliantly and creatively. It's my pleasure to share their accomplishments with you now.

Tony Macina
Vice President and General Manager
IBM Federal Systems Company
Houston, Texas



IBM HOUSTON BUSINESS PROFILE



3700 Bay Area Boulevard Building

NASA Partners for 30 Years

Our company is very proud of our longstanding relationship with NASA. The IBM Federal Systems Company in Houston has provided large, complex information management systems for every U.S. manned space flight program since 1962. Our systems can be found throughout NASA, both on the ground and on board the spacecraft. For three decades, they've performed important functions critical to the success of the space administration's mission.

Some of the NASA computer systems we have developed over the years include:

- The data processing facilities in the Mission Control Center at Johnson Space Center;
- The onboard computing system for the Gemini spacecraft, used to control the first rendezvous in space;
- The instrument unit that guided, navigated and controlled the Apollo/Saturn launch vehicle that carried men to the moon,
- The Skylab onboard computing system that operated continuously for 6,400 hours in space;
- The space shuttle's onboard avionics system that guides, navigates and controls

the orbiters in flight from launch through landing;

- The Space Shuttle Program Compliance and Status Assurance System, a management information system that keeps NASA decision makers constantly informed of the status of each mission.

IBM and NASA: Partners Today

Our facilities continue to play a critical role in the U.S. space program. Some of our current projects include:

- Providing flight and support hardware and software for the shuttle's onboard avionics system,
- Designing and developing the space station onboard Data Management System, which will process, transmit and display data from virtually every part of the station and control the operations of the station itself,
- Developing communications, guidance and mission planning software for shuttle and space station ground controllers, and
- Providing hardware, support and maintenance for the Johnson Space Center's administrative computer systems.

We employ about 1,100 full-time IBM employees and nearly 400 contractor employees in eight locations around the country. About 80 percent of our employees have one or more college degrees.

IBM's Record of Achievement

Our employees have an impressive record of achievement. For example, the IBM computers used on board the space shuttle are 45 times more reliable than NASA originally expected. The IBM software used on board the space shuttle is virtually error-free. Its quality is more than 10 times higher than the industry average.

The quality of our products is high because we put as much emphasis on the process as we do the end-product. For example, in the space shuttle project, our software programmers insert 10 times fewer errors than the industry average. More than 80 percent of those are found before independent testing begins.

A few years ago, our shuttle software development process received the highest score possible ("five" out of "five") from a team of

NASA experts who evaluated it against the rigorous standards of the Carnegie Mellon University Software Engineering Institute.

We pride ourselves on completing our projects on time and within budget. Our customers' evaluations of IBM's performance on its contracts are rarely less than NASA's rating of "excellent."

Our site was twice named IBM's "Best Software Laboratory" and received IBM's highest coveted Market-Driven Quality Award. We've won NASA's Excellence Award for Quality and Productivity both times we've applied for it--first in 1987 and again in 1992.

But we don't measure quality only by statistics and awards. The happiness and well-being of our employees is one of our highest priorities. Our team efforts contribute to making our employee morale one of the highest in IBM.

In addition, nearly 94 percent of our employees say they understand IBM's quality principles. More than 91 percent say they believe IBM lives up to its principles.

IBM's Quality Principles: Always Changing, Always the Same

Our employees did not have to be convinced of the importance of quality. IBM has always had a "quality culture." In 1963, our firm wrote down its quality principles, called our Basic Beliefs. They are simple and straightforward:

- Respect for the individual
- Excellence in all things
- Service to the customer

But our quality principles are not a lifeless monument to good intentions. Like any living thing, they have changed and evolved in response to market changes and our customers' needs.

For example, when we began developing software for the space shuttle program in 1973, we quickly realized that traditional software development methods would not produce the level of quality NASA demanded.

So in 1979, we established our Software Quality Principles to serve as a basis of assumption for re-thinking and re-making the way we develop software. Although they were new, these principles reflected the mind-set or attitude already established in our Basic Beliefs. Our error rates declined even more as soon as we put these principles in action. We still use them today as the basis for all the software we develop.

Eleven years later, we realized that quality and productivity was critical to our success in a highly competitive marketplace and we

developed a set of guidelines, our Market-Driven Quality (MDQ) Initiatives, to improve every process in the business, not just the ones we use to develop products.

Like Houston's software quality emphasis, IBM's MDQ Initiatives reflect the same strong focus on process, measurement, continuous improvement and--most importantly--empowering employees.

Basic Beliefs: 1963

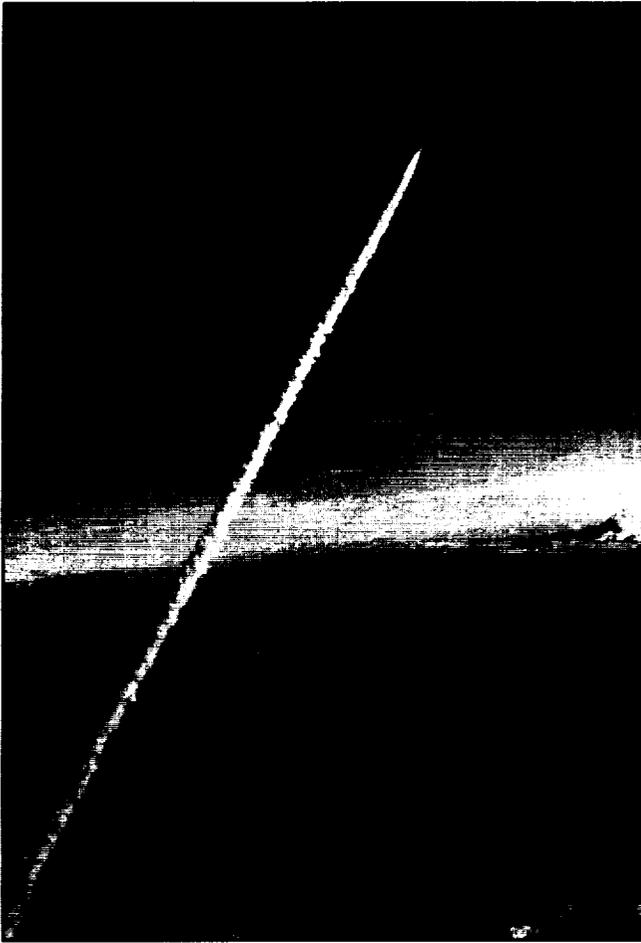
- Respect for the individual
- The best customer service in the world
- The pursuit of excellence

Software Quality Principles: 1979

- Quality improvements bring productivity improvements
- The causes of defects are removed
- The process is continually monitored, measured and improved
- The work process is well-defined and understood by everyone
- No defect is acceptable. The goal is zero errors

Market-Driven Quality: 1990

- Increase employee ownership
- Improve processes
- Measure progress
- Set quality and productivity goals



Shuttle in Flight

Large, Complex and Critical Task

The task of producing virtually error-free software and man-rated hardware for space travel is difficult by itself. But the conditions under which we work are difficult as well. The systems we develop for NASA are:

- **Large**

They often contain hundreds of pieces of equipment and millions of lines of code. For example, the software IBM developed for the Mission Control Center at Johnson Space Center contained 3.5 million lines of code. The onboard and support software we developed for the shuttle's avionics system contained nearly 2.5 million.

- **Complex**

The systems we create are a complex mix of custom-made and commercially available products--not only IBM's, but also those of other manufacturers. They often included advanced technology being tried out for the first time. Yet they must blend seamlessly with NASA's existing systems.

The systems are called upon to perform sophisticated, complex functions. For

example, the IBM computers on board the space shuttle check on each other 300 to 400 times per second to assure perfect synchronization.

The system itself is constantly changing. About 60,000 lines of shuttle software code must be reconfigured before each flight to accommodate the unique payloads and demands of the mission. At any given time, we are working on six to seven flights at once. We also may be revising or re-writing another 30,000 lines of code to add new capabilities, adapt to changes in other parts of the orbiter, or take advantage of new technology.

- **Critical**

IBM's systems must perform perfectly at all times. The success of NASA's mission depends on it. For example, aboard the space shuttle, the IBM avionics system processes data for and issues commands to all the orbiter's major subsystems, like propulsion, communications and life support. In Mission Control, IBM hardware and software keeps mission controllers constantly informed of the status of the mission and relays commands to the craft--in real time.

Five-Sigma Processes

Obviously, perfection is not merely a goal for us. It is a necessity for survival. And by necessity, we have improved our processes to the point where they often go beyond NASA's expectations.

But this did not happen overnight. Our managers and employees worked together for more than a decade to create processes that are well-defined, repeatable and consistently capable of producing products of Five Sigma quality or more. No matter what the activity, all our processes share these same four characteristics:

- **Customer-driven**

Customer participation and feedback are integral to our operation. Our goal is to find out early in the process what customers want and keep them involved until they are satisfied.

- **Prevention-based**

Our programmers have developed a mature, well-defined process that helps them make fewer initial errors and to find the ones they do make earlier in the process. The result is lower costs for our customers.

- **Constantly improving**

We are obsessed with measurements. For nearly a decade, we have been collecting and analyzing detailed data and using it to shape and drive our software processes.

- **Employee-led**

All our employees are members of at least one quality team. They, not their managers, control their processes. Employees set their own quality goals and develop their own plans for achieving them. If the process needs improving, they are responsible for changing it.

Every Individual's Responsibility

We have deliberately structured our business processes to motivate every employee to buy into the need for quality. We push responsibility down to the lowest unit of the organization.

For example, responsibility for quality does not stop with our Quality Assurance Department. Quality goals are built into every employee's individual performance plan. Pay and promotion are determined, in part, on whether the employee achieved his or her quality goals and how well he or she worked with the team. This applies to vice presidents as well as programmers. It is one of the ways we build continuous improvement into the system.

THE IBM QUALITY PROCESS

IBM's Involved Leadership

In word and deed, IBM executives send a message to employees that they are serious about quality--that they expect nothing less than perfection.

The commitment to quality starts at the top. When Tony Macina became general manager of the site in 1991, he immediately told employees,

"Products produced by the Houston site have a significant influence on NASA's space program, other government agencies, our nation's prestige, our company's reputation and, most importantly, human lives."

"The quality of those products and the degree to which they satisfy our customers determine the extent to which our site grows and prospers."

"Recognizing the importance of quality products, it is essential that all IBM Houston employees be committed to instilling quality in everything we do, to the point that our customers are satisfied to the highest extent possible and all our products are defect-free."

Macina followed up his words with action.

He meets with a first-line department once a week, the site Quality Council coordinator once a month and senior executives once a quarter to review the site's quality performance.

For the general manager and his nine senior executives, quality management is a full-time job. They devote 100 percent of their time to learning customers' needs and making sure they are satisfied, setting high goals, motivating and empowering employees to achieve those goals, providing them with the resources they need to do it, and recognizing them and rewarding them when they do.

Continuous Improvement

We manage quality the same way we manage the rest of our business. It is an inseparable part of our overall strategic business planning cycle, part of our business strategy.

Once a year, the site's business and quality goals are set by senior executives based on input from all the business areas. At that time, the senior executives establish the site's "5-Ups," or key quality measurements. For example, one "5-Up" is always customer satisfaction as measured by award fee scores. Every business area, department and key process (such as software development) then establishes its own set of "5-Ups."

Since 1988, we have considered every department a quality team, responsible for measuring, tracking and reporting its quality performance the same way it does its business performance. A Quality Council made up of representatives from each business and functional area is responsible for coordinating and communicating the site's quality activities.

The general manager meets with each senior executive once a quarter to review his or her business areas' quality performance.

“Serious about quality—nothing less than perfection”

ORIGINAL PAGE IS OF POOR QUALITY

Employee Ownership and Control

Our executives lead the quality process, but they do not drive it. They set goals for the site as a whole but refrain from imposing arbitrary measurements from above. They "own" the site's most important business processes but do not control them. Employees do.

A few years ago, our managers gave employees the power to change and improve the processes they use as they see fit. They provide them the tools and methods needed to measure performance and help them set high goals. Then the managers get out of the way.

Here's how it works. Macina delegates "ownership" of each one of the site's major business processes to a senior executive. The executives, in turn, designate a "working owner" from middle management. These working owners then divide the processes into subprocesses and hand over control--and responsibility--to the employees who work and use them.

Employees then:

- Identify their customers
- Document and analyze their process
- Define measurements, set goals
- Use the measurements to define their progress toward their goals
- Change their process, if necessary, to improve it.

The managers' role is limited to reviewing their goals and performance and rewarding them appropriately.

Customer-driven Process

Our customers are active participants in every stage of every major project. Customer representatives attend requirements reviews, inspection team meetings, major milestone reviews, status meetings, technical cost reviews and evaluations. This way our employees learn first-hand what our customers want and whether they are satisfied. If they're not, our employees can make changes early, before it's too late.

Vendors and Subcontractors: Part of the Team

Subcontractors and vendors are important to us. They perform more than 35 percent of the site's work. They are involved in virtually every part of our business, from hardware and software development to administrative and support services. We consider them part of the team.

Our philosophy is to select the best vendors and work with them to improve. Our quality

requirements are written into their contracts. Our employees evaluate their performance against the requirements at least once every three months. Most, like us, are rewarded if they meet or exceed their customer's expectations. Once a year, the best vendors receive our "IBM Supplier of the Year" award.

As part of the team, vendors attend all our project team meetings. We make a special effort to bring them in early to attend requirements and design-and-code inspections so they can better understand NASA's needs and expectations. If there is a problem, they are members of the team assigned to solve it.

THE IBM SHUTTLE SOFTWARE DEVELOPMENT PROC

Consistently Six Sigma

Nowhere can the precision of IBM's quality processes be seen better than in the way we develop guidance, navigation and control software for the space shuttle's onboard computer systems. NASA requires that this software be error-free.

To achieve that, we focus on the front end of the process. Our goal is to prevent errors before they happen and catch them early if they do. From the beginning, customers are involved in the process until they are satisfied.

Our method of developing shuttle software is not unique. We use all the standard software development methodologies -- but more. We work hard at balancing technical excellence with management discipline. We measure and control every aspect of the process--cost, schedule and performance, as well as quality.

The result is a process that consistently produces products of almost Six Sigma-level quality. Over the past 10 years, our product error declined from about two errors per thousand lines of code to almost no errors. The last two software systems we delivered contained no errors at all.

The process itself is extremely efficient. Our software programmers insert 10 times fewer errors than the industry average. More than 80 percent of those are found early in the process before independent testing begins.

Key Software Development Features

IBM's process for developing error-free software for the space shuttle is shaped by its software development principles. The key features are:

- **Employee attitude**

Our employees identify personally with the astronauts who are the end users of our products. They feel a sense of personal responsibility for quality that goes beyond mere professionalism. We start with an "edge."

- **Employee ownership**

We push responsibility for quality down to the basic level of the organization--the individual. Programmers, not managers, set the goals and control the processes to achieve them.

- **Requirements analysis**

Employees study customers' requirements early to avoid misunderstandings about what the customer wants or expects.

- **Configuration control**

We use advanced technology, such as automated software development tools, sophisticated algorithms and error prediction models, to control every aspect of the process from start to finish.

- **Error cause analysis**

Our employees use a rigorous, four-step method to find errors and prevent their happening again.

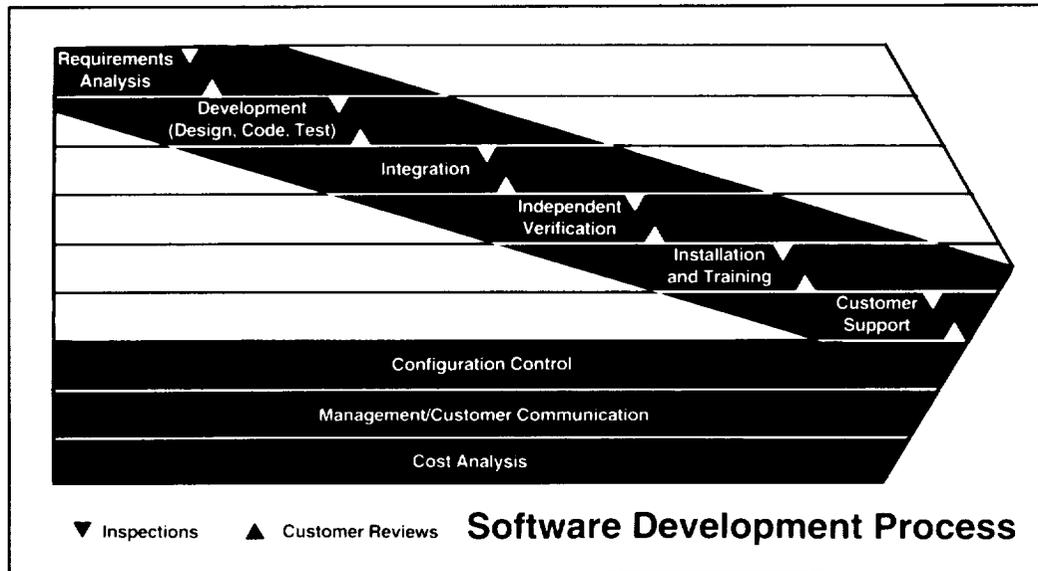
- **Continuous improvement**

The process is deliberately structured to encourage change and improvement through regular self-analysis and new technology.

first of a series of inspection team meetings, which are held at critical points in the process. The inspection teams are made up of customers and employees representing each part of the process, from requirements definition to testing. Their job is to review every requirement and every line of code. They follow a rigorous, predefined agenda that includes audits, checklists and computer-generated reports.

All the inspection teams' findings are documented in a configuration management data base, a set of software tools used to control the content of the software and to monitor every phase of the process. The data base records and tracks all errors and concerns throughout the life cycle of the product.

At the first inspection team meetings, NASA approves the requirements from which we will work and we then enter the baseline into the configuration data base. After this point, requirements cannot be changed without the permission of the Baseline Control Board.



Rigorous Six-step Process

We use a rigorous, six-step process to develop software for space flight.

Our aim, as always, is to create a product that:

- Meets the letter and intent of the customer's requirements
- Performs to the customer's unwritten expectations
- Is completely free of errors.

Step 1: Requirements analysis

Before one line of code is written, trained requirements analysts study NASA's specifications to make sure they are clear, complete, compatible with the rest of the shuttle's onboard systems and implementable as written.

The analysts present their findings at the

Step 2: Software development

After the requirements are analyzed, checked with the customer and documented in the database, actual programming begins. Our programmers use top-down, structured programming methods and well-defined, strictly enforced standards to code software. They work at individual workstations linked to IBM and customer databases, where they have access to a variety of automated tools designed to prevent errors.

After the code is written, the inspection team meets again to make sure the design implements the requirements and the code implements the design. The code is then tested at the line, module and function level to make sure it meets both the letter and intent of the requirements.

Step 3: Integration

After the code is tested, the modules are assembled and integrated into a complete system. The process of inserting new or changed code into the shuttle's existing software system is automated to reduce the chance of inserting an error. As each line of code enters the system, it is automatically checked against

meeting at every phase of the process so that they have a thorough understanding of the software's purpose and design. They then use that knowledge to develop comprehensive and rigorous test plans and procedures.

These workers are responsible for verifying the code at the line, module, function, subsystem and system level. To do that, they use a wide variety of test methods, such as checklists, audits and test cases. They test the code against the requirements ("black box"), the design ("white box") and a combination of the two ("gray box").

The results of their tests are reviewed with the customer before the product is certified as ready for delivery to NASA.

Step 5: Installation and training

Our employees install, integrate and test the software in the customer's own environment. The development process is not complete until NASA's testing and acceptance process is complete.

IBM trains NASA software users with interactive multimedia programs, simulation programs and expert systems. Part of our goal is to help our customers understand our product better so they can get more out of it. This approach we think improves customer satisfaction in the long run.

Step 6: Customer support

After the system is up and running, IBM employees remain at the customers' side to help them get the most out of the product and to learn more about what they need, want and expect in the future.

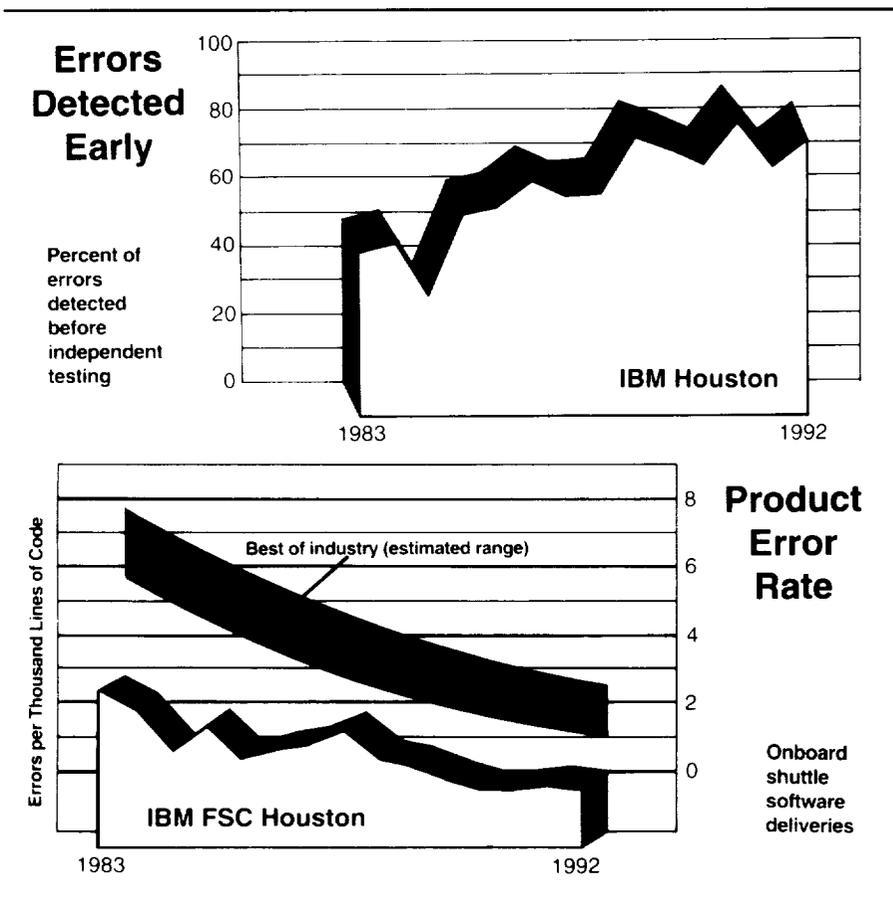
Error Cause Analysis: Key to Continuous Improvement

The process we use to develop onboard software for the space shuttle is carefully structured to promote continuous change and improvement.

Few errors get through our tightly controlled process, but when they do, our software developers don't just investigate the error--they investigate the whole process. Special teams cover every phase of the process to find out the error that escaped detection.

A rigorous, four-step approach is used. First, the error is found and fixed. Second, the cause of the error is found and eliminated. Third, the fault in the process that allowed the error to slip through the process is fixed. Lastly, similar, as-yet-undetected errors are sought and eliminated, too.

After the investigators have gone through all four steps and done everything they can



Error Detection and Rate Graphs

the configuration management data base. If it doesn't match the baseline, the code is rejected and returned to the programmers for correction.

Step 4: Independent verification

IBM's independent verification experts maintain a healthy adversarial relationship with the software's developers. They assume that the software has never been tested and that it contains hidden errors they must find.

The verifiers attend every inspection team

to prevent that kind of error from happening again, they analyze the error data to look for trends. If they conclude that the process needs to be changed and improved, they inform the process evaluation team, which implements the changes.

These employee-run teams are responsible for maintaining the quality, integrity and efficiency of the processes they own. Anyone--employee, customer or supplier--can submit a recommendation to the process evaluation team. The team evaluates the suggestion, implements and documents any changes and effectively closes the loop on the error prevention process.

Definable, Repeatable Process

We were so pleased with the results of our shuttle software development process that a few years ago we began applying it to our other software processes and even our business processes, such as finance, administration and human resources. We were delighted to find out that the principles work no matter what the activity.

Take employee education, for example--a process very different from software development. Our Education Department staff found ways to increase the amount of education and training our employees receive by 85 percent and at the same time reduce costs by 42 percent. Best of all, our employees tell us that they are nearly 100 percent satisfied with the training and education they are getting.

■ **"Perks"**

We encourage our managers to be creative at finding ways of showing IBM's appreciation. Some managers give their outstanding employees "rides" in the shuttle simulator and tickets to view a shuttle launch at Kennedy Space Center. Others allow their employees to "dress casual" or treat themselves to snacks when they've done a particularly good job.

In 1991, 92 percent of our employees said they were satisfied with the recognition they received.

More Education at Less Cost

We invest heavily in training and education to keep our employees up-to-date. We offer graduate work/study programs, on-the-job training programs, interactive multimedia programs, self-guided manual and video training, traditional classroom and laboratory courses, seminars, lectures, satellite courses and specialized simulators.

An Education Advisory Board was formed, made up representatives from every business area, to work with the Education Department to determine the site's education needs and develop a plan, budget and curriculum for the year. We track and measure the type, amount and quality of education being delivered. Our employees are considered our primary customer. We track indicators to determine if they are satisfied with the evaluation they are receiving.

"We use a variety of methods to recognize and reward teams for outstanding contributions above and beyond their normal duties."

HUMAN RESOURCES

Employee Recognition

We use a variety of methods to recognize and reward both individuals and teams for outstanding contributions above and beyond their normal duties.

■ **Cash**

About 25 percent of our employees receive some form of monetary award every year. Individuals may receive awards ranging from \$150-\$2,500 for informal contributions to \$100,000 for suggestions that save the company money.

■ **Special events**

Our employees say they particularly enjoy special events. For example, we hosted a seated luncheon for all our employees when we won the 1987 NASA Excellence Award. We held a barbecue for the Onboard Shuttle Software team when they completed their second release of error-free software.

Every employee who takes a course is asked to evaluate it on a scale from 1 (high) to 5 (low). The average course was rated 1.9.

Recently, we've been trying to lower the cost--but not the quantity or quality--of education at our site. We began offering more courses off company time, introduced more automated instruction and developed alternate ways of disseminating information.

For example, we use a companywide satellite system to reduce travel expenses. Instructors conduct classes for IBM employees in 28 locations on such topics as planning, computer science, programming, communications, finance, manufacturing, technology and IBM products. The classes are "live" and completely interactive. About 10 percent of all our site's education is conducted over the satellite system.

In the past few years, we increased the total



Employees in Team Meeting

number of student days of education by 85 percent and lowered costs by 42 percent. In 1990 our employees received an average of 6.5 days of education each, three times more than the national average.

Proactive, Preventive Health and Safety

We are committed to giving our employees a safe and healthy place to work, with many goals set higher than government requirements.

We take a proactive approach to safety, working to prevent illnesses and injuries. We believe that managers and employees share the responsibility for achieving that aim.

Because most of our employees work at computer terminals, we put special emphasis on ergonomics. For example, to prevent eye strain, we provide every employee who spends more than 20 percent of his or her workday at a computer terminal with a new pair of prescription eyeglasses once of year free of charge. To prevent wrist, neck and back strain, we automatically give employees ergonomically-designed wrist pads, foot stools and other aids.

In 1990, we had nearly 10 times fewer injuries per employee than the industry average. Nearly 98 percent of our employees say they are satisfied with working conditions in Houston.

We also take a proactive approach to health. Through our "A Plan for Life" program, employees can take advantage of free courses on

weight control, smoking cessation, stress management or nutrition, among others. Last year, more than two-thirds of our employees enrolled in 40 on-site and off-site classes.

A Scientific Approach to Morale

For more than 25 years, IBM has scientifically surveyed all its employees every 18 months. We ask them (anonymously) what they think about their job, manager, salary, career opportunity and overall satisfaction.

The results of the survey are distributed to our managers, who analyze them and take action to correct problem areas. Employee morale in Houston has improved steadily since 1988 as a result of these efforts. Today, our morale rating is one of the highest in the corporation.

PRODUCTIVITY AND SCHEDULE/COST CONTROL

Capital Investments to Improve Productivity

We carefully plan our capital investments to improve quality, increase productivity and lower the cost of doing business. We have had a strategic investment plan to automate office and product processes since 1983. Over the past decade, we have spent millions of dollars in computer equipment and software tools specially tailored to the kind of work we do.

Since 1988, all our employees have had their own personal workstations with access to a host computer, national and corporate networks and a wide variety of software tools, including spreadsheets, graphics and databases.

Our software programmers have access to specially adapted automated software tools to encourage reuse. For example, after we began using these tools in 1983, the amount of work needed to reconfigure software for each shuttle flight dropped by more than 50 percent. Overall, our software developers are nearly twice as productive as their industry counterparts in real-time, life-critical applications and up to three times more productive in non-life-critical applications. One of our most productive investments has been the "Team Focus" Decision Center, a room where members of a team can "brainstorm" with each other silently and anonymously over a network of personal

computers. Communicating with each other by computer helps remove the fear of criticism that obstructs the free flow of ideas. The computer organizes and records the data discussed at the meeting and takes "votes" on the ideas that are offered. It helps a team analyze a problem and reach a consensus in a fraction of the time. We have found that it reduces meeting time by at least 50 percent.

Our investments in productivity tools have clearly paid off. The amount of revenue produced by each employee increased nearly 75 percent from 1988 through 1991.

This year, we started a new program to motivate our employees to help keep productivity rising. They receive cash bonuses based on the company's return on assets. In the first year of the program, employees received 3.8 percent of their salary in incentive pay.

Integrated Cost Control and Schedule Management

We do not believe in quality at any cost. To us, bringing a project in on time and within budget is as important as the quality of the product itself. Special automated software tools were developed to take the guesswork out of controlling the costs and managing the major project schedules.

Since 1986, we have used a process called the Schedule Management System (SMS) to manage cost, schedule and technical performance. SMS gives project managers a single master database with detailed information on all the project's costs, schedules, milestones, product deliveries and tasks and who is responsible for them. It gives everyone involved a visible overview of the status of their part of the project and the project as a whole. It generates written weekly status reports or more often, if necessary, and customizes the reports, if desired. In that way, it enforces accountability and acts as an early warning system for potential problems.

We also developed the Software Cost and Quality Engineering Starter Set (SQUESS) to help us avoid overruns by better predicting labor costs. It automatically calculates the costs of software development projects based on their size, complexity, degree of mission criticality and product quality requirements. It also estimates the number of people and identifies the types of skills needed to finish the project successfully. It can be used either before a project is begun to allocate resources or after a project is underway to adjust to changes in the customer's requirements. It has proven to be an

accurate and reliable predictor in nearly 15 years of use.

We're proud that we have never missed a deadline for a major software delivery. In 1990, we delivered 90 percent of our products on time. In the past three years, every one of our major projects has come in within 10 percent of budget. Our average project comes in one percent under budget.

Management Initiatives to Control Costs

Our executives have taken active steps to make IBM more competitive and reduce costs to the customer.

In 1991, we reorganized our business and created a separate company, called the IBM Federal Sector Services Corporation, to offer systems design, engineering, integration and maintenance services. The move is expected to save NASA more than \$2 million in lower overhead costs and general/administrative rates in 1992 alone.



Team Focus (Decision Support Center)

ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH

Benchmarking--a Necessity and a Responsibility

We've done extensive research to find out where we stand in relation to our competitors--and help them find out where they stand in relation to us.

For example, in 1990, we visited Motorola Corporation, winner of the first Malcolm Baldrige National Quality Award, to learn more about its administrative practices.

In 1991, we hosted a conference with the Union of Japanese Scientists and Engineers (JUSE) to share information on software development and quality processes.

It is estimated that Japanese software developers are 70 percent more productive than their U.S. counterparts and produce less than half as many defects. The conference was attended by 30 software engineers from 10 leading Japanese companies and universities and several representatives from NASA.

From our research, we learned that IBM Houston is "best of breed" in several categories, including software quality. Our software errors rates range between zero and .3 errors per thousand lines of code compared to the industry average of three errors per thousand lines. Many companies, like Boeing and Motorola, and other IBM sites, like the Baldrige Award-winning Rochester plant, use IBM Houston as their benchmark.

IBM in the Community

One of IBM's highest priorities is improving science education in the U.S. In Houston, IBM is involved in several high-profile projects:

- **Space Center Houston**

IBM has contributed more than \$1.5 million to sponsor a new education and entertainment complex at the Johnson Space Center. The IBM "Feel of Space" exhibit uses computer simulators to help visitors (many of them children) feel what it's like to be an astronaut.

- **Partners in Space**

IBM sponsors a program to develop a 4th-to-8th-grade curriculum that uses space exploration to excite children's interest in science. Eleven local school districts, six aerospace companies, Johnson Space Center, the Texas Education Agency, and the University of Houston-Clear Lake also are partners in the program.

- **Total Quality Management (TQM) Grants**

In 1992, IBM gave eight U.S. colleges and universities up to \$3 million each in cash and equipment to help them develop curricula and conduct research on quality.

The University of Houston-Clear Lake, our partner in many quality-related projects, received a \$2-million TQM grant from IBM.

- **Challenger Center**

IBM contributed \$100,000 in cash and equipment to the nonprofit Challenger Center for Space Science Education, dedicated to providing exciting, innovative learning experiences to help prepare middle-school children for life in a technological world.

ACKNOWLEDGEMENTS

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If you would like more information on the George M. Low Trophy; its history, the process, the criteria used for evaluation, or past recipients of the award; please contact:

Office of Continual Improvement
NASA HEADQUARTERS, Code T
Washington, DC 20546

PAST RECIPIENTS

1987
Martin Marietta Michoud Aerospace
13800 Old Gentilly Road
New Orleans, LA 70189

IBM Federal Sector Division
3700 Bay Area Boulevard
Houston, TX 77058-1199

1988
Rockwell International Corporation
Rocketdyne Division
6633 Canoga Avenue
Canoga Park, CA 91304

1989
Lockheed Engineering & Sciences Company
2400 NASA Road One
Houston, TX 77058

1990
Marotta Scientific Controls, Inc.
78 Boonton Avenue
P.O. Box 42
Montville, NJ 07045-0427

1990
Rockwell International Corporation
Space Systems Division
12214 Lakewood Boulevard
Downey, CA 90241

1991
Grumman Technical Services Division
1250 Grumman Place
Titusville, FL 32780

Thiokol Corporation
Space Operations
P.O. Box 707
Brigham City, UT 84302-0707

1992
Honeywell Incorporated
Space Systems Group
13350 U.S. Hwy 19N
Clearwater, FL 34624

IBM Federal Systems Company
3700 Bay Area Boulevard
Houston, TX 70058-1199



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